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# MODIA: Vol. I
# Overview of a Tool for Planning the Use of Air Force Training Resources

Polly Carpenter-Huffman

A Project AIR FORCE report
prepared for the
United States Air Force







Rand
SANTA MONICA, CA. 90406

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A description of MODIA (a Method of Designing Instructional Alternatives), a system developed to help Air Training Command (ATC) plan technical courses. This, the first in a series of five reports, introduces the series by describing MODIA's rationale, structure, and support requirements and by discussing the results of ATC's evaluation of its effectiveness as an aid to course planning. Technical training offers both the potential for effecting substantial improvements in training efficiency and ample opportunities to improve efficiency through redesign of courses. MODIA helps the Air Force achieve these goals by (1) systematically relating quantitative requirements for training resources to the details of course design and operation during the planning stage and (2) computerizing course design to encourage the examination of alternative designs. ATC's evaluation of MODIA showed that it does help planners design more efficient courses. Its potential value to ATC, however, hinges on management issues, which ATC is currently addressing in a follow-on evaluation. (Author)

# PREFACE

This report documents research conducted under Project AIR FORCE (formerly Project RAND) by The Rand Corporation. The work described here was performed as part of the project entitled "Analysis of Systems for Air Force Education and Training" under Rand's Manpower, Personnel, and Training Program. It is the first in a series presenting Rand's MODIA planning system. MODIA, a *M*ethod *O*f *D*esigning *I*nstructional *A*lternatives, is a system of people, computer programs, and procedures that allows the rapid specification and simulation of courses of instruction during the early stages of instructional design. It augments and can be used in the present Air Force instructional systems development process.

The development of MODIA has been supported by the Deputy Chief of Staff/ Personnel, Headquarters United States Air Force, and the Air Training Command, especially DCS/Technical Training, the Training Development Directorate, and personnel at the Keesler School of Applied Aerospace Sciences. It is part of Rand's continuing research effort in the areas of planning and management in education, education technology, and the cost and effectiveness of education systems.

The series of MODIA reports includes:

R-1700-AF, *MODIA: Vol. 1, Overview of a Tool for Planning the Use of Air Force Training Resources*, Polly Carpenter-Huffman.

R-1701-AF, *MODIA: Vol. 2, Options for Course Design*, Polly Carpenter-Huffman.

R-1702-AF, *MODIA: Vol. 3, Operation and Design of the User Interface*, Polly Carpenter-Huffman and Ray Pyles.

R-1703-AF, *MODIA: Vol. 4, The Resource Utilization Model for Instructional Course Design*, Margaret Gallegos.

R-1704-AF, *MODIA: Vol. 5, A User's Guide to the Cost Model*, Ron Hess and Phyllis Kantar.

This report introduces the series by telling the reader in general terms why MODIA was developed, what it does, and what it is.

MODIA is the product of many people. The author is especially indebted to Bernard Rostker, director of Rand's Manpower, Personnel, and Training Program, whose unflagging support has made MODIA possible. Ray Pyles contributed the discussion of MODIA's relation to steps in planning, and suggestions from Robert Rippey, Philip Doughty, and Helen Turin improved the clarity and completeness of this report. Marilyn La Prell typed the original manuscript. Sally Belford prepared the pasteup for printing.

## CONTENTS

# I. INTRODUCTION

## PURPOSE AND ORGANIZATION OF THIS REPORT

MODIA is a complex system; the subsequent reports describing it are detailed and, at times, technically demanding. This report tells the reader in general terms why MODIA was developed, what it does, and what it is. After this Introduction, which discusses the why of MODIA, Sec. II describes MODIA from several points of view. Section III presents an example of its application to a training course. The last section discusses the evaluation of MODIA by the Keesler School of Applied Aerospace Sciences.

## THE PROBLEM

The Air Force is heavily involved in training; in peacetime almost all Air Force activities may be considered as training of one kind or another. The most visible and highly structured of these activities is conducted by Air Training Command (ATC)—Basic Military Training, Flying Training, and Technical Training—a multi-billion dollar enterprise requiring the support and involvement of over 12 percent of Air Force personnel.

The largest single component of ATC is devoted to formal Technical Training, which prepares Air Force personnel for jobs ranging from aircraft maintenance to personnel administration. In 1976, some 150,000 persons—over a quarter of the force—were scheduled to graduate from formal courses given in established technical schools.[1] The operating cost of this activity was to be over $600 million; 9 percent of Air Force personnel were to be engaged in such training at any particular time. Because of its large student load, formal Technical Training offers opportunities for realizing large dollar savings, even though such savings are small in terms of the individual student.

Many opportunities to improve the management of training resources arise in the normal course of events. There are currently some 300,000 different course hours in the curriculum, of which over a third are substantially revised or newly prepared annually. Changes in force composition, introduction of new weapon systems, and changes in operating policies of other commands all affect the subject matter of training and can have direct effects on requirements for training equipment and indirect effects on training operations. Shifts in training-related characteristics of the student population (such as general academic ability or previous experience related to the subject matter of the course) may require changes in teaching method or shifts in subject matter emphasis. Changes in school policy toward classroom management may encourage the replacement of familiar methods with new teaching materials or techniques. Finally, variations in requirements for the output of graduates obviously and strongly affect the availability of and requirements for training resources.

[1] Derived from *Military Manpower Training Report for FY 1977*, Department of Defense, March 1976, pp. I-10 and B-9.

Clearly the design and redesign of courses, if accomplished more effectively, could lead to substantial improvements in training. The current Air Force approach to course design, termed Instructional System Development (ISD), is outlined in AFM 50-2.[2] ISD is a systematic procedure for relating the content and conduct of training to needs in the field. This procedure consists of five steps:

1. Analyze system requirements—determine what tasks should be performed on the job.
2. Define education or training requirements—determine how and where performance of these tasks will be learned.
3. Develop the objectives and tests for instruction.
4. Plan, develop, and internally validate instruction.
5. Conduct instruction and evaluate its effectiveness both internally and in the field.

In carrying out these steps, training developers are guided by the general principles stated in AFM 50-2, tempered by their own judgment and past experience and by existing school policies and procedures.[3]

Such expertise is requisite to skillful application of ISD, but course planners have lacked assistance in two key areas. First, they have had no way to examine the requirements for training resources implicit in a particular course design. Instead, to estimate resource requirements, they have had to use planning factors (e.g., the average student-to-instructor ratio) based on past school experience. As a result, resource requirements have entered the design process only in a gross, subjective fashion or after course design was completed. The demands for bookkeeping and computation attendant on constructing and costing a course design has meant that only rarely has more than one design been considered during planning.

Second, they have not been able to explore the effects of variations in teaching strategy on course design in a systematic and comprehensive fashion. Rather, changes in teaching strategy have been constructed bit by bit during the production of the course. The effects of these changes, unfolding as the revised course has been put into operation, have often been unforeseen. The inability to uncover such possibilities during the planning stage has discouraged the design of courses that depart significantly from past practice.

## PURPOSE OF MODIA

MODIA was developed to help the Air Force manage resources for formal training by systematically and explicitly relating quantitative requirements for training resources to the details of course design and course operation during the planning stage. *Course design* includes selection and sequencing of subject matter; placement and description of tests; deciding on teaching methods and the roles of instructors and other training personnel; the assignment of media, training equipment, and facilities; and specifying the characteristics of the trainees and policies

[2] *Instructional System Development*, Department of the Air Force, AF Manual 50-2, 31 July 1975.

[3] Quantitative approaches to training development are partly incorporated at step 1, in establishing the tasks commonly performed in the field, and at steps 4 and 5, in internal validation and field evaluation.

for the management of student progress. *Course operation* simulates the way student progress through the course and the resulting requirements for and use of training resources would be affected by these design decisions. Thus MODIA (1) suggests approaches to course design not incorporated in available planning factors and (2) describes the effects of course design on resource use. This encourages course developers to consider *alternative* designs; as the acronym implies, the consideration of alternatives is MODIA's primary objective.

MODIA is *not* a prescription for training, nor is it an optimizing model; rather, it is neutral with regard to the training effectiveness of a course design in terms of student learning or with regard to the desirability of a course design in terms of training policy. Although it does not prescribe a particular course design and is neutral with regard to training effectiveness, MODIA insures that planners make all the design decisions necessary for rational planning. Although it does not optimize, MODIA gives planners the data they need to make their own judgments in comparing alternative plans. Through an interactive, iterative process it encourages planners to consider, for example:

- The implications of the subject matter for requirements for training resources and teaching strategy;
- Characteristics of students that affect learning and instruction;
- The effects of course management policies and teaching strategy on learning and on the use of training resources; and
- How changes in one element of course design will affect the others.

MODIA has been designed primarily for the use of the five ATC technical schools, which account for over 90 percent of the student load in technical courses. Each school has several departments, and each department deals with a major subject area and has several branches that are responsible for the training in a related group of courses. MODIA is directed to the course level because a student usually takes only one course at one school to qualify for his initial job assignment.

Although MODIA has been designed for use by course planners, its usefulness is not restricted to the school level. On the contrary, MODIA would be very helpful to higher headquarters for examining the implications for the specifics of school operation of broad changes in training policy.

The most fruitful applications of MODIA will probably be in Step 4 of ISD—in the planning and development of instruction. However, like ISD itself, MODIA can be applied at any of several stages of planning. For example, MODIA does not require that all objectives and tests be stated in criterion-referenced terms or even that all be identified before it can give insight into course development. As with the steps in ISD, among which feedback and interaction should refine and improve the ultimate result,[4] MODIA should be applied at different levels of generality. For example, in early stages of planning MODIA may show that with a given student load there is not enough training equipment for each student to have sufficient practice on it. This might suggest that some of the equipment-oriented objectives could be redirected toward less expensive mockups, computer simulation, or other acceptable substitutes. Thus, MODIA has numerous slots for descriptive data that do not all have to be filled accurately before results can be useful. Moreover,

[4] AFM 50-2, p. 1-2.

MODIA can be an aid for planning only a portion of a course (e.g., a block or single module of instruction) or for planning up to four courses that use the same training resources simultaneously.

## II. DESCRIPTION OF MODIA

This section describes MODIA from several points of view. Of most immediate interest to potential users of the system are its requirements for inputs and its outputs, answers to the questions: "What do I have to know to use the system?" and "What do I get out of it?" Next, the components of the system and the relationships among them are described. The role of each component in planning is then discussed.

### INPUTS AND OUTPUTS

MODIA's major requirements for input are specification of:

- Whether the course will require unusually expensive or scarce resources.
- What course content is and how it should be sequenced, especially with regard to those portions requiring the use of unusual resources.
- The maximum and minimum numbers of students that can be expected to take the course during the period of interest.
- Whether tests will affect student progress in the course and at what points they will be given.
- How each unit of the course will be taught.
- How long it will take to teach the course, especially those parts of it that require unusual resources. This implies that the user is familiar with the content of the course and characteristics of the students who will be taking it, and has some idea of how long it takes students with those characteristics to learn the given type of content when instructed by the methods the user chooses to specify. This is MODIA's most demanding requirement for input.
- The percentage of entering students who may be eliminated from the course or required to repeat portions of it.
- The availability and unit cost of resources used by the course.

The more accurately the foregoing are known, the more useful MODIA's output will be. Even where knowledge is lacking, MODIA can be used to test the sensitivity of course operation and cost to variations in the unknown quantities.

From the inputs described above, MODIA derives the following outputs:

- Average and peak student loads.
- Average time before graduation or elimination from the course.
- Time during which students are waiting for other students (when students are taught in groups larger than one) or for resources (when resources are limited).
- The percent of time each resource is used.
- The number of resources required, if they are furnished as needed.

- The capacity required of a resource, if it is unknown and to be furnished as needed.
- The start-up, annual, and five-year cost of the course.

## COMPONENTS OF MODIA

People are the most important component of MODIA. As with any tool, MODIA's product is only as good as the user can make it. Skillful application of MODIA requires not only the expertise described in the requirements for input but thorough familiarity with the system and imagination in its application. Since it is highly unlikely that all of these qualities will be found in a single person, "the user" will usually be several people, each bringing his own special skills and experience to bear on the problem of course design.

Because the bulk of MODIA resides in computer programs, users may in a very short time generate a blueprint for instruction and estimates of the resources needed to produce and operate the resulting training course. More important, computerization encourages users to design and compare alternative plans before the course specified by a particular plan is produced and put into operation, often a long and expensive process. Once a baseline course design has been constructed, alternatives can be generated in a matter of hours or minutes, depending on the degree to which they depart from the baseline and the richness of the baseline design.

MODIA has four components: the description of options for course design, the User Interface (UI), the Resource Utilization Model (RUM), and the Cost Model (MODCOM). Figure 1 shows the interactions between the user and these components. Note that MODIA has two main points for entering data—the UI and MODCOM—rather than automatically translating RUM output into course cost. This is because decisions concerning costing procedures and policies are often contingent on course operation. The additional entry point also permits planners to refine the design for preferred course operation before undertaking a complete cost analysis.

The separation of entry points has a further advantage; most of the information that is unique to ATC is captured in MODCOM, so that the UI and RUM are useful for planning training in a wider range of institutional settings. Thus, the UI and RUM can give insights for planning parts of courses, rather than full courses, or courses given in the Air Force Academy, the Air University, or other Air Force agencies. Conversely, ATC can use MODCOM independently of the UI and RUM to analyze course cost without requiring access to the considerably larger resources (computer capacity and MODIA analysts) required to support the UI and RUM.

The *Options for Course Design* (Vol. 2) provides an overview of the data and information the UI will ask for, the range of choices available at each entry point, and the pros and cons of each choice as they affect course operation, cost, or instructional effectiveness.

The UI is an interactive computer program; that is, the user enters data step by step in response to questions from the computer. The choice of question the computer asks at a given point is influenced by preceding responses from the user, hence the term "interactive." Also, at many intermediate points, the computer processes the set of answers given to that point and displays the results to guide

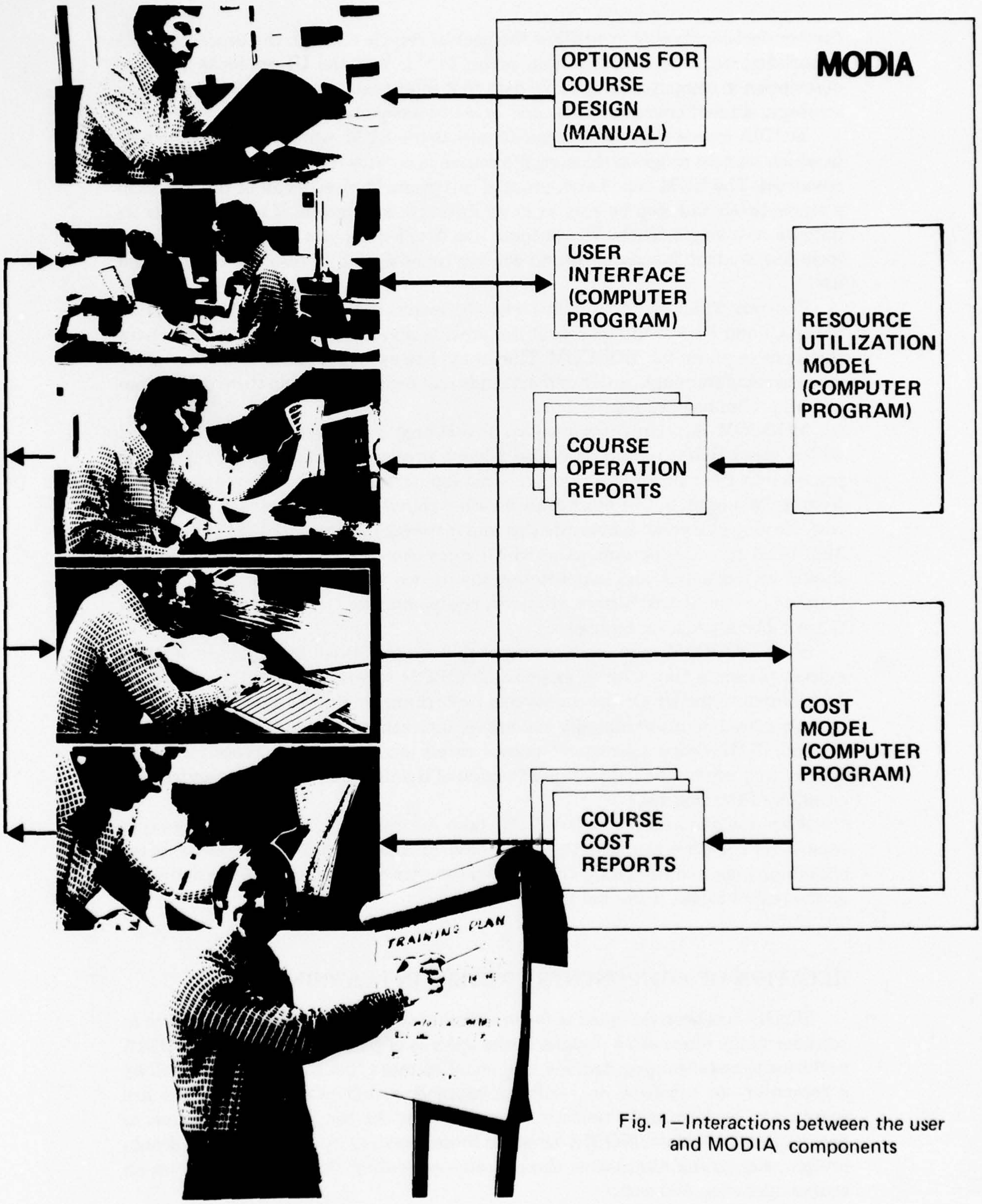


Fig. 1—Interactions between the user and MODIA components

further decisionmaking or to allow the user to recycle through the process if he is dissatisfied with the results at that point. In this way the UI produces a course description in computer-compatible data that interrelates course content, teaching strategy, student characteristics, and resource assignments.

MODIA inputs these data automatically to the RUM, which simulates the way in which student progress through the course generates requirements for training resources. The RUM is a "batch process" program: It receives all of the inputs in a single batch, not step by step as in an interactive program. It also produces its outputs in a single batch. The outputs are detailed reports on course operation including student flow patterns and waiting times as well as resource demand and use.

Planners will rarely be satisfied with the results of the first complete operation of the UI and RUM and will repeat the process several times before they prepare the input required for MODCOM. They may, however, use MODCOM at an early stage to compare rough, order-of-magnitude cost estimates to help them select from among preliminary course designs.

MODCOM estimates the five-year investment and operating cost associated with a given course design. It is also a batch process program, but its inputs are provided by the planner. He can take some inputs, such as resource requirements, from RUM output, but he must draw on other sources for such items as equipment cost. He may also want to override cost and manning factors stored in the program. MODCOM provides options as to which costs should be included and how they should be computed, and supplies outputs in two formats, one relating costs to training resources (instructors, students, equipment, etc.) and one to categories in the Air Force program budget.

Since MODCOM requires some input that is not a direct consequence of RUM output, planners may wish to exercise MODCOM several times without revising initial input to the UI. Or the course cost reports may highlight a feature of course operation that is unwarrantedly expensive, indicating additional operation of the UI and RUM. Since subsequent passes rarely entail complete redesign of the course, they often take only a small fraction of the time and attention required for creation of the first case.

When the planners are satisfied with both the course operation and course cost reports for a specific course design, they have at hand the bulk of the elements for a training plan and need only synchronize the plan with other planning activities at the school to put it in final form.

## RELATION OF COMPONENTS TO STEPS IN PLANNING

MODIA has been designed to be an assistant to planners, encouraging them to consider many alternative designs in the process of planning the course. MODIA performs time-consuming, tedious, and complex tasks that are performed well by a computer—to calculate, to verify, to categorize, and to simulate. People are required to perform tasks that are done poorly by the computer—to conceive, to design, and to evaluate. MODIA assists in these functions by structuring the design process, suggesting alternative choices, and estimating the effects of choices on course operation and cost.

Course planning may be thought of as three operations. Given the objectives for a particular course, first a design for that course may be synthesized, then that design may be analyzed to determine its cost and operating characteristics, and finally the design may be evaluated against some desired goal or other alternative designs. Figure 2 shows the relation of MODIA's components to these steps. The Options for Course Design and the UI aid in the synthesis of the course design, and the RUM and MODCOM constitute the major portion of the second function, to analyze the course design. The planner performs the evaluation.

In the synthesis of alternative designs, planners may attempt to attain certain educational objectives within the constraints of school policy, the resources on hand, budget available to buy new resources, types and kinds of instructors available, and types and numbers of students expected. They must combine these factors with knowledge of the subject matter, some educational psychology, and some common sense to arrive at a design for the course. Within these constraints, they have considerable freedom to design the course they believe will best attain the educational objectives. For example, they can determine the type of material to be presented, its sequence, the mechanisms for presenting it, and which students will receive what material. Such a design process is largely inductive, subjective, and innovative, qualities seldom associated with computers.

During the synthesis of alternative designs, each decision must be checked to verify that there are no internal conflicts among decisions made at different points in the design process and that no part of the design is left out. For example, there must be an instructional policy for all objectives in the course and the resource requirements implicit in each policy must have been considered. Therefore, the primary roles assigned to the UI for synthesis are to assure that each alternative design is internally consistent and complete, and to translate each into data that are compatible with the programs that subsequently analyze the course design.

The analysis of alternative designs requires careful, detailed estimation of the performance of the course in several respects, including training effectiveness, graduation rates, failure rates, bottlenecks in student progress, and cost. In most cases, planners currently perform the analysis manually using institutional rules of thumb, personal educational wisdom, and a combination of intuition and inspiration. Although MODIA cannot predict the instructional effectiveness of the course —the ability of the course to produce students with a particular set of skills—the RUM can estimate its operational performance and MODCOM, its cost. Thus, the planner's knowledge of the instructional value of particular training methods is augmented by MODIA's analysis of cost and operational performance.

Evaluation of the alternative designs is another subjective process requiring the weighing of the various performance measures to select an acceptable or best course design from the alternatives. There is no single best way to do this, because different schools have different criteria of excellence. For example, one school may be particularly concerned with the cost of instructors while another may trade increased cost for higher performance. Since such a rich variety of considerations must be balanced in the evaluation of alternative designs, it seems unlikely that a computer program can be written that would ultimately select the "best" course design for a particular course. Therefore, this entire function is best performed by human planners.

One tool that is frequently proposed to assist in the choice among alternatives is "cost-effectiveness" analysis. In general, the alternatives designed with MODIA

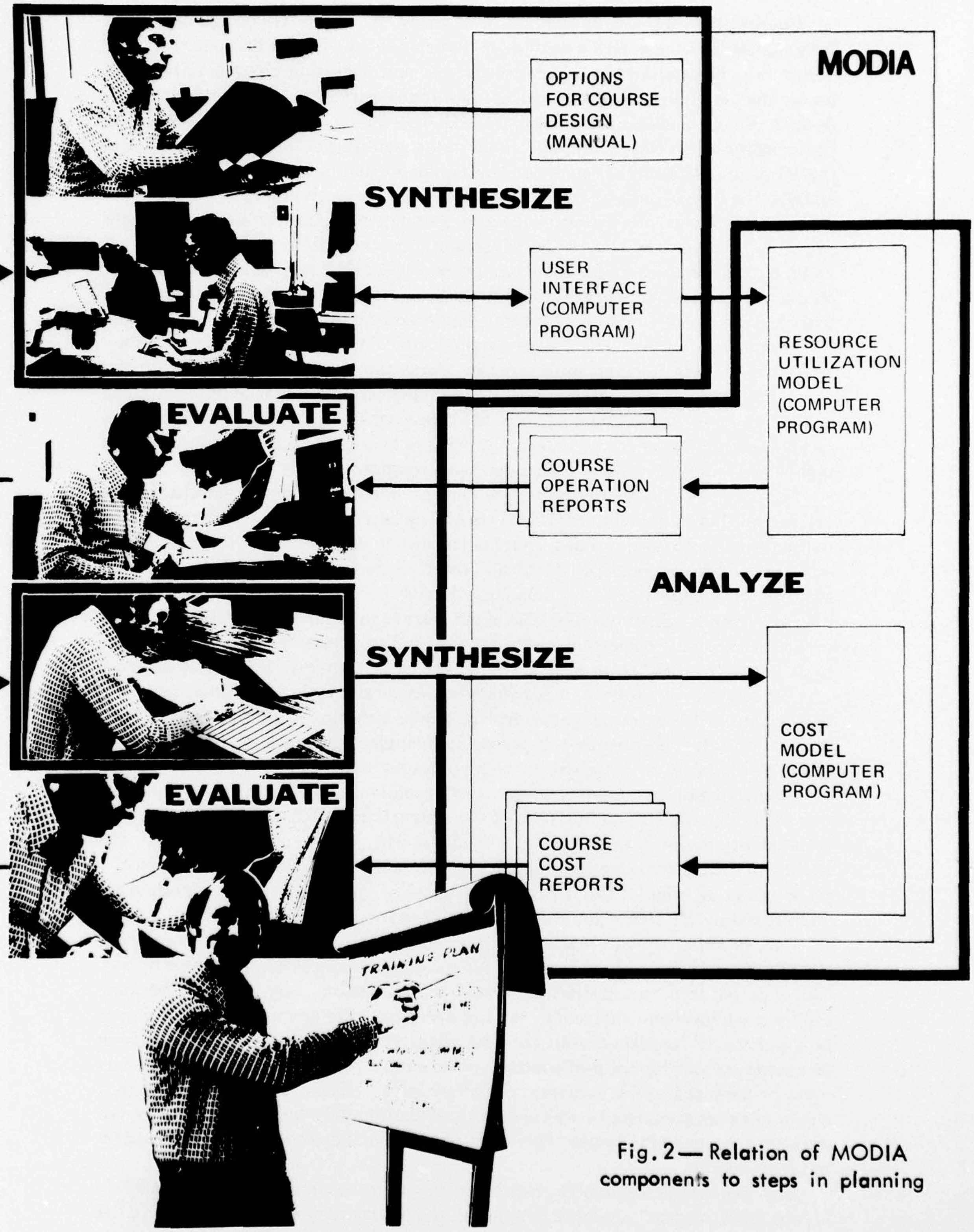


Fig. 2—Relation of MODIA components to steps in planning

will vary in *both* cost and effectiveness. They can be compared with absolute standards, such as budgetary constraints or minimum required instructional effectiveness, and with each other. One might be rejected because it violates the standards, another because it is similar in cost (or effectiveness) to other alternatives but of much less effectiveness (or greater cost).[1] Where there is no clear-cut rationale for choice, the alternative will be chosen that has the greatest subjective appeal to the planner. It is important to stress that, as will be illustrated in the next section, comparisons of cost or effectiveness should not be made among designs that have different levels of detail regarding comparable elements, such as the specification of resources. Although not all elements need be defined in the same detail, comparisons among designs with different levels of refinement for comparable elements will usually not be valid. In other words, to define comparable cases, all elements whose cost is likely to differ significantly should be included.

## RESOURCES REQUIRED TO SUPPORT MODIA

MODIA is currently operating in two installations, the Keesler School of Applied Aerospace Science near Biloxi, Mississippi, and The Rand Corporation in Santa Monica, California. Each of these provides a different instance of how MODIA can be supported. For example, the primary MODIA computer at Keesler is the Honeywell 6060, whereas at Rand it is the IBM 370/158.

Below is a discussion of the resources needed to support MODIA and the minimum standards they should meet. In general, these standards are such that components that must be readily accessible to school planners can be supported at any of ATC's technical schools. The RUM, which, because it uses SIMSCRIPT II.5, may need to be operated remotely, does not have to be at the planner's fingertips.

### Personnel

Competent people are crucial to the effective use of MODIA. Two groups should be involved in any application of MODIA in planning—those who are expert in using MODIA (hereafter referred to as "the MODIA team") and those who have knowledge and experience in the areas of subject matter and planning particular to the course being developed (hereafter referred to as the "subject matter experts"). Figure 3 shows the configuration currently in use at Keesler.

Members of the MODIA team need not (and probably should not) have extensive experience with computers. By background and bent they should be problem solvers first, computer experts second. They need to be familiar with course planning and school operations, so that they can draw out the subject matter experts' best judgment on what constitutes effective instruction and help them distinguish between what is usually done (for convenience or by tradition) from what is needed. They should also have a feeling for how far school policies can be adjusted and if it would be desirable to do so, and they should be able to act as liaison among different organizational entities within the school whose interests may clash within a given training course design.

[1] For a comprehensive discussion of this process of analysis, see Carpenter and Haggart, *Cost Effectiveness Analysis for Educational Planning*, The Rand Corporation, P-4327, March 1970.

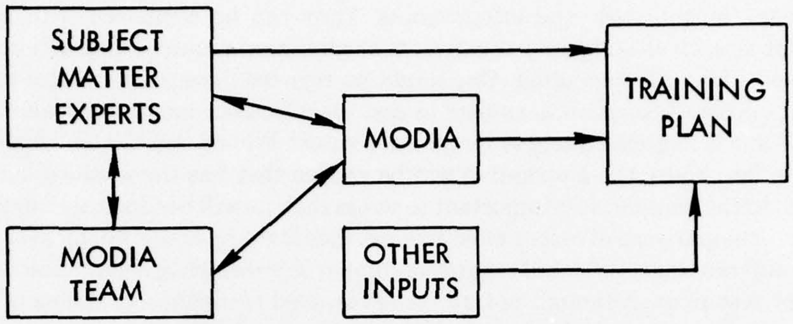


Fig. 3—Configuration currently in use in Keesler School of Applied Aerospace Science

Members of the MODIA team need initial training in the use of the system and need to apply the system frequently enough to maintain their expertise. They should be fully aware of MODIA's features and operation, particularly of the alternatives it encompasses; should have a good feel for the effects of different choices of input on MODIA outputs; and should be able to guide the subject matter experts in choosing the most efficient alternatives.

The subject matter experts are people who normally plan and develop courses. They need an understanding not only of the subject of the course but of the student population and the teaching methods that work best for them. They should be familiar with school policy and should know what resources are likely to be available to the course and what they will cost. All of this information need not reside in a single person (nor does it in the current development process). Perhaps most important, the subject matter experts need to be flexible—able to interact with the MODIA team so that the special capabilities of both groups can be fully applied.

**Configuration of Hardware and Facilities**

Two features of the system configuration are of overriding importance to course planners—responsiveness and accessibility. Planners should be able to use the system at almost any time during the working day so they can fit MODIA in with their other normal duties, and they should have access to MODIA in locations that are convenient to their usual places of work and free from undue distractions. These characteristics are particularly crucial to the use of the UI, which ideally should be operated from a portable terminal.

To facilitate the smooth flow of the design process, the computer should process and respond to inputs to the UI within five seconds of the completion of input for at least 90 percent of such completions. Response times for the batch programs (RUM and MODCOM) need not be so short. (Response time for a batch program is the time from job submission to the return of printed output to the user, including communication time if a remote facility is used.) Response times for batch programs should not exceed 24 hours for 95 percent of the jobs submitted. Otherwise,

the interactive, iterative nature of the design process will be destroyed. Of course, it is highly desirable for all response times to be as short as possible; they will normally vary depending on the extensiveness of the course design, the operating system and hardware, and the number and size of competing jobs being performed on the computer.

The MODIA hardware and facilities should be arranged in two groups—a computer facility and one or more working areas. In the computer facility are all of the computer hardware except the interactive terminal—the computer, card reader, high-speed printer, and other supporting hardware—while the working areas are outfitted like a normal office (with desks, chairs, chalkboards, filing cabinets, storage shelves, telephones, and other office equipment and supplies) with the addition of the interactive remote terminal. Such arrangements allow the planners to work privately, away from the activity of the computer facility for much of the time and in closer contact with their own documents, preliminary course plans, and other materials necessary to the planning activity. MODCOM uses keypunched card input, so arrangements will also be needed for occasional keypunch support.

Computer system requirements for supporting MODIA are given in the appendix.

# III. AN APPLICATION OF MODIA

The most direct way to acquaint people with MODIA is through a concrete example. This example illustrates some of the:

- inputs MODIA uses and outputs it produces;
- ways in which MODIA stimulates the design of alternatives;
- levels of refinement in training plans that can be considered.

The example does not by any means demonstrate all of MODIA'S features. More exhaustive examples are developed in the other reports in this series.

## BASIS OF THE EXAMPLE

The example is based on the first major section (or "block")[1] of course 3ABR30431, Flight Facilities Equipment Repairmen, as it was taught at the Keesler School of Applied Aerospace Sciences in the fall of 1973 and described by Keesler personnel who were expert in this subject matter. The example is carried through the other reports in the series.

This block of the course oriented the student to general characteristics of the job for which he was being trained and taught him fundamental skills and procedures for maintaining the AN/URN-5 (a low frequency beacon). Almost all students who entered the course had completed an 18-week course in electronic principles (3AQR30020). As of October 1973 the course for Flight Facilities Equipment Repairmen lasted for 17 weeks, so that the total training for those who graduated was 35 weeks. Students taking this course must have scored at or above the 80th percentile in the Electronic Aptitude battery of the Airman's Qualifying Examination. Thus they tended to be above the average airman with regard to both general academic ability and knowledge of electronics.

## ORIGINAL BLOCK DESIGN

### Training Content

The goal of the block was to prepare airmen to maintain the AN/URN-5 low frequency beacon, a ground-based device used in air navigation. Maintenance consisted of various procedures for servicing the beacon, troubleshooting the beacon when it malfunctioned, checking it during aircraft flight, and installing it in a flight facility. Only knowledge of procedures for the last two tasks were taught, rather than ability to perform them.

The example includes the following content and sequence, and the time required for instruction:

[1] "Block" is ATC terminology for a portion of a course that teaches one or two major topics. Frequently a block deals with an item of major equipment, as in this example.

*Test Equipment.* The trainee was familiarized with the equipment used to service and test the AN/URN-5 (2-1/2 hours).

*System Familiarization.* The trainee learned what the components of the AN/URN-5 were and how to read the schematics associated with it (8 hours).

*Servicing.* The trainee learned to perform a simple procedure for servicing the beacon (1/2 hour).

*Schematics.* The trainee learned to analyze more detailed schematics for the system (6 hours).

*Servicing.* The performance of more complex procedures for servicing the AN/URN-5 was taught next (1-1/2 hours).

*Principles of Troubleshooting.* Fundamental principles to be applied in troubleshooting electronic equipment were taught (1-1/2 hours).

*Troubleshoot AN/URN-5.* The trainee learned to find the cause of malfunctions induced by the instructor (1-1/2 hours).

*Flight Checking.* The trainee learned what procedures were used for checking beacon operation during aircraft flight (3/4 hour).

*Installation.* The trainee learned what procedures were used for installing the beacon in a flight facility (3/4 hour).

*Written Test.* A test was given emphasizing the trainee's ability to read schematics (1/2 hour).

*Practical Test.* Next, the trainee was tested on his ability to perform one of the servicing procedures (1/2 hour).

*Critique.* The block ended with the instructor discussing test results with the class (1/4 hour).

## Teaching Method

The instructor used the discussion-demonstration method to teach the facts and concepts required; this classroom work was supplemented by assignments for home study. He spent the largest share of his time guiding student practice in reading schematics, also supplementing the activity with home study. Students performed on the equipment (servicing and troubleshooting) in teams of two, with the instructor providing guidance as needed.

## Student Entries and Repeats

A maximum of eight students was expected to enter each week. From past experience, Keesler subject matter experts expected 15 percent of the students to do so badly on the test that they would have to take the block over again. No student would be eliminated from the course on the basis of test results.

## Resource Characteristics

Major resources used were the instructor, the AN/URN-5, a classroom for general instruction, and a lab housing the equipment.

*Instructor.* The instructor could handle up to ten students in conventional classroom work but could supervise only four during performance on equipment. Thus, at times three instructors would be needed during student performance to accommodate students repeating the block.

*AN/URN-5.* Only two students could work on one low-frequency beacon at a time. Therefore, five beacons would be needed, again to accommodate repeating students.

*Classroom.* This would be a standard classroom with a capacity for ten students.

*Lab.* The lab would contain the five beacons and space for up to ten students to work on them.

## MODIA OUTPUTS FOR ORIGINAL BLOCK DESIGN

The above information was entered in the UI and MODCOM. With regard to course operation, MODIA shows that although the block length is just over 24 hours (24 hours and 15 minutes), the average time a student spends in the course is more like 32-3/4 hours because of the relatively high percentage of students who must repeat the block and because repeating students have to wait to join classes entering later. Similarly, although the average student load would be 6.4 students (because the block length is shorter than the entry interval) without student repeats, it is actually nearly nine students because of the repeats. Finally, because resources have been supplied to meet peak demands, which occur during only a small portion of the course (student performance on equipment), most resources are used very little. For example, the low-frequency beacons are used only 12 percent of the time, and the instructors are occupied only 34 percent of the time.

Assuming that the block is taught in this way for a period of five years and that all resources must be acquired at the outset, this block of instruction would cost at least[2] $839 thousand (not counting the cost of overhead). Given the underutilization of resources noted above, it is natural to ask whether a redesign of the block might result in better use of fewer resources and, hence, a lower cost.

## AN ALTERNATIVE DESIGN

Although an objective of redesign might be to reduce cost, another objective might be to improve the training effectiveness of the block at the same time. For example, a special track might be formed for slower students so that the instructor could concentrate his attention on them in smaller classes. Bright students, who compose the bulk of trainees in this career field, could learn mainly through self-instruction. Letting the brighter students progress at their own pace would also have the effect of staggering the demands for resources so that peak demands would occur at different times for the two tracks; this could solve some of the resource problems posed above.

Specifically, assume that 40 percent of the students belong in the slow track where they are instructed by an instructor. The brighter students work largely on their own with "scrambled"[3] books in a study area within the laboratory, where

[2] "At least" because many resources that would be required have not been include in this estimate.

[3] A "scrambled" book presents the subject in small units, each followed by a question testing the student's grasp of the unit. The sequence of units a student reads is determined by his choice of response to each unit.

another instructor can answer questions as necessary. It takes the bright students about 3/4 as long to complete the self-study assignments as the slow students spend with the instructor learning the same materials. All students work on the equipment in teams of two, as before, with the instructor responsible for monitoring the work of no more than two teams at a time.

To establish an upper bound on the resources required for this alternative, we first ask MODIA to compute the number of resources required if they are to be furnished as needed. Some outputs from this computation are shown in Table 1, along with data on the base case.

The five-year cost for the base case shown on Table 1 has been raised to $842,000 (from $839,000) to include the cost of development and procurement of printed materials for comparison with the materials for self-study used in the alternative, which are more expensive to develop. This illustrates a general principle: To define comparable cases, all areas where costs are likely to differ should be included.

The upper bound case (column 2 in Table 1) was not costed because it seemed likely that a less expensive case could be designed by reducing the stock of resources that are used very little. This turned out to be true, as the third column shows, where the number of low-frequency beacons has been reduced from four to three. Although the alternative uses the same number of instructors as the original design, it uses them for somewhat more of the time (53 percent rather than 34 percent). This is because of the way students tend to distribute themselves in self-paced study.

The case shown in column 3 is somewhat less expensive than the base case, primarily because of the reduced length of the block. Would it be more effective in teaching the subject? If so, perhaps the recycle rate would actually drop enough to permit the use of one less instructor. This would result in another 7 percent saving over the base case. Whether a sufficiently large drop in recycles would result from the changed approach can only be established in actual application.

Table 1

Comparison of Alternative Block Designs

| | Base Case | MODIA Revised (unlimited resources) | MODIA Revised (limited resources) |
|---|---|---|---|
| Average student load | 8.7 | 7.2 | 7.2 |
| Peak student load | 13.0 | 12.0 | 12.0 |
| Average time to finish block | 32:44 | 26:54 | 26:58 |
| Resources | | | |
| Low-frequency beacon | | | |
| Number | 5 | 4 | 3 |
| Percent of time used | 12 | 12 | 16 |
| Instructors | | | |
| Number | 3 | 3 | 3 |
| Percent of time used | 34 | 53 | 53 |
| Five-year cost (thousands) | $842 | (not costed) | $789 |

# IV. EVALUATION OF MODIA

During the spring of 1976, personnel of the Keesler SAAS evaluated MODIA in an operating Air Force setting. In this section, the objectives of the evaluation, the procedures used to carry it out, and the results[1] are discussed.

## OBJECTIVES AND PROCEDURES

The objectives of the evaluation were "to determine the validity of the course operation and course cost data (MODIA) generates, to assess its effectiveness as a planning tool, to determine its implementation and potential operating costs, and to determine to which types of formal technical training the system can be applied."[2] The major criterion of planning effectiveness was to be that courses produced with MODIA would be sufficiently less expensive than existing courses to offset the additional cost (if any) of using MODIA.

These objectives were established by personnel at Hq ATC and at Keesler; Keesler designed, directed, analyzed, and reported on the evaluation. Although Rand provided assistance and suggestions as requested before the evaluation began, Rand did not participate in the evaluation beyond helping Keesler operate the computer programs.

At about the time MODIA was being installed at Keesler, a group of people at the Lowry SAAS began designing a new course to train technical instructors to apply less traditional teaching methods, such as computer-assisted instruction. At Lowry's request, Keesler included this course in the evaluation. Thus, MODIA was also applied to an entirely new course for the evaluation.

The formal evaluation began after the Keesler MODIA team had become familiar with the system and Rand had made a major revision to the UI at their request. The first step was to establish MODIA's validity by using it to simulate courses and comparing the resulting estimates of course operation and cost with historical data describing the same characteristics for existing courses. Five courses were chosen that had recently been revised manually through application of ISD and were considered products of high-quality planning. The comparison was made for the courses as they had been before revision, since complete cost and operation data were not available for the revised courses. A team of three to five subject matter specialists worked with the MODIA team to insure the accuracy of the simulation and the cost factors entered into MODCOM for each course. During this activity, careful records of resource consumption (primarily personnel and computer time) were maintained.

Next, each course as it had been revised manually was simulated and costed using MODIA to establish a baseline case for comparison with alternatives designed with the help of MODIA. Of course, no baseline was available for comparison

[1] *Evaluation of the MODIA System*, ATC PR 76-1 USAF School of Applied Aerospace Sciences, Keesler AFB, Mississippi, July 30, 1976.
[2] Ibid, p. ii.

with designs that the planners produced for the Lowry course. Two alternatives were prepared in addition to each of the baseline courses. Again, the subject matter specialists worked with the MODIA team, and careful records were kept of resource use.

Concurrently, the Keesler evaluators gathered information describing the magnitude of the Keesler manual planning activity in terms both of the percentage of total course hours that are new or revised annually and the amount of personnel time that had been spent in manual planning of the five baseline courses. At the end of the evaluation, structured interviews of the MODIA team and the subject matter experts who had participated in the evaluation were conducted "to determine their perception of MODIA's value as a planning tool and to identify factors affecting its effectiveness."[3]

## RESULTS

For four of the courses simulated by MODIA, course cost and operation parameters were within 2 to 8 percent of those reported for the courses before manual revision. (The Keesler Comptroller considers MODIA cost estimates to be sufficiently valid if they are within 10 percent of the comptroller's cost figure.) One course (3AQR30020-1, Electronics Principles), however, was outside the specified range. This course, taught by the self-paced method, has a large number of modules of instruction and a very large student load. The simulation kept track of each student as he moved through each module at an individually assigned rate. The resulting mass of data was so large that the planners could simulate only 600 hours of course operation, rather than the 1500 hours annually devoted to this course.

For three of the baseline courses resulting from the manual planning process, the alternatives generated with the assistance of MODIA were less expensive than the baseline courses as simulated in MODIA. For one course, neither of the alternatives designed with the assistance of MODIA was less expensive than the baseline course. For another, the Electronics Principles course discussed earlier, planners designed an alternative using MODIA that was 8 percent (or $4,000,000) less expensive than the baseline. However, both the baseline and the alternative were derived by extrapolation from a 600-hour simulation, so the validity of this saving is open to considerable question.

Although the Lowry planners devised a course design with MODIA's assistance that they felt would be optimum, they also were unable to simulate their preferred design as accurately as they wished. Subsequently, Rand personnel helped them produce a more accurate simulation of the course they had in mind so that they could answer several of their questions about the course design.

Manual planning is not comparable to planning using MODIA because MODIA-assisted planning produces several alternatives, whereas in manual planning the "perceived single best course design is pursued from the beginning." Also, manual planning almost always represents less radical degrees of revision than the MODIA approach.[4] Therefore comparison of the cost of planning using MODIA with the

[3] Ibid, p. 22.
[4] Ibid., p. 28.

cost of manual planning is not valid; however, knowledge of MODIA's applicability and costs is essential in deciding whether MODIA is worth its costs.

More than half of the hours in courses to which MODIA can be applied at Keesler are new or revised annually (42,500 hours); this represents 80 percent of Keesler's annual planning effort.[5] Because of this wide applicability, the evaluators concluded that when the savings that the evaluation indicated are possible in the courses tested are "projected to the population of courses to which MODIA can be applied" they outweigh MODIA's operational cost.[6]

Perhaps most important over the long run were the improvements MODIA made in the planning process. Personnel involved in the test believe that MODIA will enable users to:

- Accurately plan new and revised courses. ISD team members believed that the courses simulated by MODIA had a great deal of fidelity to the actual courses so that they could have confidence in the products generated by MODIA during course planning.
- Systematically design a course by providing guidance that assists planners in making the major design decisions.
- Rapidly plan instructional alternatives once planning data have been collected and worksheets prepared. It required, on the average, three days of intense over-the-shoulder guidance by the MODIA team for each ISD team to collect and translate course planning data to MODIA parameters for system operation. However, this was all accomplished in about one-fourth the time required to plan one instructional alternative manually.
- Consider many options in planning instructional alternatives.
- Rapidly compare the consequences and costs of alternative decisions concerning an instructional system. From MODIA printouts, team members were able to identify areas of a course (especially in resource utilization) that could be improved. Although they had to use their own judgment to devise the changes that might improve the course, MODIA quickly gave them feedback on the consequences of these changes. Therefore, in an operational environment, planners could repeatedly modify the simulated course until an optimum mix of instructors, materials, equipment, facilities, and sequence of learning events was found.[7]
- However, it is apparent that enthusiastic support for MODIA will evolve only if a competent and innovative MODIA Team explains the system, provides guidance and insights, and interprets the computer products.[8]

The evaluators did not recommend adoption of MODIA, not only because they believed that the data resulting from the test were too limited to do so, but, more important, because "It has not yet been determined how SAAS policies and objectives will be integrated into MODIA planning, and at what level the products of MODIA will be used in decision making.... Further, neither operating procedures nor the necessary operational configuration to support MODIA planning have been

[5] Ibid., pp. 26 and 33.
[6] Ibid., p. 32.
[7] The above material paraphrases points made in *Evaluation of the MODIA System*, p. 22.
[8] Ibid., p. 33.

determined."[9] The evaluators concluded by recommending a follow-on evaluation to "establish both the procedures and organizational configuration necessary to support MODIA planning, and using realistic management problems, establish the utility of the system to SAAS management."[10]

## SUMMARY

The Keesler evaluation of MODIA is a valuable contribution to the literature on planning in addition to being a useful report on the strengths and weaknesses of MODIA. The evaluation revealed that:

- MODIA performed as it was designed to do; in particular, it helped planners design more efficient courses.
- There are several technical ways in which MODIA can be made more useful.
- Personnel costs for using MODIA are fairly low but the computer costs are high. These can be more than offset by reductions in course cost that MODIA encourages.
- MODIA's potential value to ATC hinges on personnel-related issues, namely the insight and inventiveness of the MODIA team, management procedures for using MODIA products, and the incentives for school planners to effect savings in all types of training resources.

[9] Ibid., p. 33.
[10] Ibid.

# APPENDIX

# COMPUTER SYSTEM REQUIREMENTS

Since it may be necessary to install different MODIA programs on different computers, the computer system requirements are presented separately for each of the three programs—the UI, RUM, and MODCOM.

## USER INTERFACE

1. Digital computer with at least 330 K bytes of problem space (exclusive of operating system).
2. ANSI[1] FORTRAN (or higher) compiler for computer.
3. Remote input/output (hard-copy) terminal with at least 72 characters per line and a data rate of at least 10 characters per second. (A portable terminal and higher character rates are very desirable.)
4. FORTRAN-callable subroutines for remote terminal input or output.
5. A medium (card punch, magnetic tape, or sequential disk file) for transmission of course design to RUM.
6. Overlay capability or conditional job steps in the system loader/operating system.
7. The computer system should be time-shared with the capability during normal working hours to begin processing 90 percent of the user responses within five seconds after the response is entered.
8. Disk program storage of at least 800 K bytes.
9. Working disk sequential file storage of at least 70 K bytes.

## RESOURCE UTILIZATION MODEL

1. Digital computer with between 600 and 1200 K bytes of problem space (exclusive of operating system). Core requirements can be reduced by using overlays.
2. SIMSCRIPT II (or higher) compiler for computer.
3. High speed printer with 132 characters per line and a data rate of at least 200 lines per minute.
4. A medium (card reader, magnetic tape, or sequential disk file) for reception of course design from UI.
5. Disk or tape program storage of at least 700 K bytes.

[1] American National Standards Institute.

**MODCOM**

1. Digital computer with at least 162 K bytes of problem space (exclusive of operating system).
2. ANSI FORTRAN (or higher) compiler for computer.
3. Card reader (80 column card) with a data rate of at least 100 cards per minute.
4. High-speed printer with 132 character lines and a data rate of at least 200 lines per minute.
5. Disk or tape program storage of at least 190 K bytes.